The Journal
of the
Mysore Agricultural
and
Experimental Union

Vol. XIV. No. 3

Economic Reconstruction in Europe*

BY

S. V. Ramamurthi, M.A., I.C.S.
Director of Agriculture, Madras

I remember with much pleasure the last occasion on which I addressed you in Bangalore. It was about 8 years back under the auspices of the Indian Mathematical Society. I spoke to the meeting on a somewhat abstruse subject—Mathematics, Science and Philosophy. It was a great pleasure to me that the cultured audience of Bangalore could hear me on such a subject with such kind attention as they showed. Last time I spoke in Bangalore, I spoke on the laws of Physics. The laws of Physics are, as everybody knows, derived from the crude material which experimental Physicists furnish to Mathematicians. It was found a few years ago that the data of Physics had so altered and been added to that the laws of Physics which had been evolved from the previous data were no longer true. We know the example of the law of gravitation which Newton laid down and which has been found to be untrue in the light of further experimental data. When the data failed to be satisfied by the laws then formulated, people looked out to see whether there were any missing links in the data, which the laws forgot to take into

* Lecture delivered under the auspices of the Union on the 22nd July 1934.

consideration. And it is the belief of Mathematicians who are leaders in England and who have also become pioneers of modern thought that mind is the missing link in Physics. When I went to Cambridge two or three months ago I asked a prominent Indian there, of whom we were all proud and who was a fellow of my old College, what people thought of Jeans and Eddington who have been talking of mind as the missing link in Physics. He said, "They are great men; but just on this point they are mad." I said he was wrong. The men whom the majority of Mathematicians considered to be mad were just the leaders who would take Mathematics in England out of the bog in which it is. But it seems to me that the confusion in Physics is not worse confounded than the confusion in Economics. As in Physics, the laws of Economics are evolved from the crude material of economic life as lived by nations and as moulded by statesmen, which is furnished to Economists. It is the life that they find which furnishes the material from which the laws are made, just as Grammar is made from the language that men learn to speak. Therefore in Europe the need is felt for a new formulation of the laws of Economics. Before the war, in leading countries of Europe, Economics was studied mainly as a science of capital and labour. In some of the leading countries, they thought that land was going to waste. They were concerned with buying raw material grown in Asia and America to convert it into machine-made products in Europe and with that buy the food that they needed. But something like a change in the economic climate of Europe has taken place after the war. Asia and America are no longer content to send raw materials to Europe. They too have begun to convert them into industrial products, with the result that Europe can no longer sell the goods that she can make even when she gets raw materials. Twenty years ago when I was attending lectures on Economics under Mr. J. M. Keynes he told us that agricultural countries would have their day and that by and by they would become much more important than the industrial nations because the competition in industrial products was bound to become severe. It is true that the importance of agricultural countries is now recognized much more than it was 20 years ago, but not in the way Mr. Keynes foresaw. It is not now the question of increasing severity of competition for all the range of purchases of raw materials and sales of industrial products. What has

now happened is that the range of competition itself has greatly narrowed down and there is little to compete for. Not only has the trade of Europe in industrial products and food with Asia and America dwindled but even among the European nations international trade has also dwindled on account of war debts, reparations and the one way traffic of gold towards America and France. It has not been possible for even European nations to keep up their old level of international trade, with the result that each country must make the food which it needs because it can no longer buy it with other goods. Therefore, in place of the economics of capital and labour which dominated the attention of Economists before the war, the economics of land has now got to be restudied in greater fulness than it was before. We know in this country economics of land has always been important for us and when the trouble as regards the marketing of industrial products began in Europe and America, we too were hard hit by it.

When I went to Rome to the International Institute of Agricultural Research, I asked the Chief Economist there whether he could give me any literature on the marketing of agricultural products in internal markets, as that was our great problem. He said that that was a problem which had not yet been studied and that he would like to have an expert at the International Institute to study marketing. He said there was some literature available in America about marketing round one market but that the problem of two markets had not been studied. When I went to England I met the late Minister for Agriculture, Dr. Addison. I was attending a commission for organizing marketing in one particular commodity. Dr. Addison is the real author of the Agricultural Marketing Act of 1931. He said that he found the Economists no good under the new conditions that had arisen ; therefore he had to depend on his common sense and draw up the Agricultural Act of 1931 and this has been added to by another of 1933. These two Acts are the basis of the elaborate organization of marketing of agricultural products in England that we see now. Germany, in the last one year, has also been following closely the methods adopted by England. This agricultural marketing in internal markets is a new area of economic activity and the laws of this have not yet been formulated. Old laws do not apply to it and administrators and statesmen are now applying empirical methods. All the products to which this

Marketing Act in England has been applied relate to food. They have been following different methods for different products because they had no theory when they started. They had a rough and ready organization to deal with any product and they find out the best way in which they could achieve what they want from their experience with each particular product. They recognize that the man who produces these essential articles must have a sufficient return. Otherwise he has no inducement to produce it further. In the case of sugar-beet they gave a subsidy to the producer of sugar hoping thereby that he would be able to give a reasonable price to the producer of sugar-beet. In the case of wheat, they gave a subsidy to the producer of wheat; but they collected the amount from the manufacturer of flour and from the importer of flour. In the case of milk, all the milk in England is now sold by one authority, the Milk Marketing Board, who fix the prices in consultation with a body of manufacturers and dealers, their negotiations being subject to control by a Board of Arbitrators. The Marketing Board give the same amount to any producer of milk, whether the milk is used for liquid consumption or for manufacture into cheese and butter. I know two or three months ago somebody sold milk at a price 6*d*. less than the one fixed. He said it was quite economic to sell at that rate; but he was convicted as the whole organization would be affected if one sold at a lower price. For bacon and pigs they control the prices by fixing prices in relation to the prices of feeding stuffs. For potatoes they control the prices by controlling the imports and production. In the case of hops, the hops Marketing board fix the price in consultation with the beer factory owners who use them. In every one of these things to which the Marketing Act has been applied, the methods applied have been different. Roughly they consist of control of production, control of imports and control of prices and they do not apply the same methods to the whole area of England. They are quite willing to take note of regional differences and make suitable adjustments. There is a similar procedure in Germany in regard to wheat. Germany is more or less self-sufficient as regards the production of wheat. They have surveyed the whole of Germany and found out large centres of production and large centres of consumption and kept them linked together in the economic interests of the whole nation. They fix the price of wheat every month by

means of an Economic Council consisting of producers, manufacturers and dealers and the interests of consumers are safeguarded by the Minister of Agriculture. They also have similar arrangements as regards the other food products like rye, milk, etc. Generally you will find in almost all important countries of Europe, the prices of wheat are kept up at a reasonable level by means of applying one or other of the methods. All this is done in a purely empirical way. Economic life is growing according to the needs of the times and the construction of economic theories is yet to follow.

Europe not having been accustomed to growing of the food that it needs has not only got to make the best of the land already under cultivation but has also got to get more land under cultivation wherever it can and large schemes of reclamation have been undertaken, in Italy and in Germany in particular. The particular principle which they use in their schemes of land reclamation is that the cultivator should pay for the benefits that he gets and that the nation should pay for the benefits which accrue to the nation. Under the old economics anybody who wanted to undertake new cultivation chose the land at his own pleasure and at his own risk. Now it is recognized that the extension of cultivation and the increase of food-supply of the nation is not merely the concern of particular individuals acting under the stimulus of individual profits but that it is a matter of vital interest to the nation itself and that the nation should share the burdens along with the cultivator. This is the essential principle on which the land reclamation schemes both in Italy and in Germany are based and the principle is worked somewhat in different ways in those countries.

Thus what is needed towards the reconstruction of economic theory and knowledge and action in Europe is in one direction the reconstruction of the economics of land and that is a subject which is of urgent interest to us in this country also. Therefore, it is to be hoped that the economists of India will collaborate with the economists of Europe in studying the new material that the economic life in these nations is furnishing and draw lessons and laws from them which not only can be used in Europe but also can be used by us adjusted to our own conditions. That is one direction in which I feel economic reconstruction is taking place and is about to take place in Europe. But there has been a large change in the life of

Europe. That is a commonplace. We know that when any group of things makes a large change of orientation some factors which remained constant formerly, also change and if you want to study the revised laws you not only deal with what may be called the variables of the old order (before the orientation) but add one or two new variables. Supposing you take a floor and you want to study the relative position and motions of the chairs and tables on it. You take the level of the floor as a constant. But supposing the floor was in Bihar. After the earthquake, one part of the floor goes up and another goes down. A chair is turned up and a table turned down. Now if you want to study the Geometry and Physics of the group of chairs and tables you have to take account of a new variable, *i.e.*, the level of the floor. Life in Europe has now been largely reshuffled by that great earthquake known as the Great War. This has introduced some more variables into the life of Europe and we may have to recast some of our economic theories taking these into consideration. I suggest mind as one such variable. I think that mind as a means of production has not been studied in the old Economics. Economics has listed the means of production as capital, labour and land. Why not mind ? Of course, mind in some aspect may be akin to labour. Mind in motion, mind as kinetic energy is analogous to labour. But the potential aspect of mind makes it more analogous to land and capital. Supposing you gave the same amount of capital, labour and land to an Englishman and to a Hottentot. Surely the economic results out of these three means of production when controlled by the mind of an Englishman would be very different from that when controlled by the mind of the Hottentot. Here it is the mind which makes the result of economic production something which varies. Therefore, it seems to me that the economics of mind has got to be studied along with the economics of land, which has now displaced the economics of capital and labour in importance.

I think that in the new countries such as Italy and Russia, the importance of mind as a means of production is beginning to be cognized or is recognized. In both the countries there is a large spread of education. In Russia 10 years ago the literacy was about 50 per cent. During the last 10 years by very determined efforts they have been able to liquidate their illiteracy entirely, so that to-day they claim to be 100 per cent literate. By literacy I do not mean

merely the capacity to write and read. They are just the symbols of a habit of ideas flowing through the mind. It is like draining and irrigating land. Supposing you have swampy land. If you drain it and if you irrigate it, the land becomes cultivable. If the mind of a man is swampy, it requires to be drained and irrigated by means of ideas. To take another analogy there is a house with all its doors and windows shut. There is no ventilation. Fine breezes will blow all round the house but nothing goes in. Just open the windows. It gets the habit of air blowing in. Both in Italy and Russia, where the people are now largely dominated by the idea of increasing economic production, the economic value of a general education is fully recognized. And not only that ; they also recognize the economic value of scientific research. The results of scientific research are something like the manure which would fertilize the land after you drain it and irrigate it. In Italy they consider it worthwhile to spend money on filling the minds of the masses with the results of scientific research. They spend a good deal on propaganda, on demonstration, on education and on getting ideas of scientific research into the minds of the cultivators and they find it economically worthwhile.

In Russia, in Leningrad I visited the Institute of Plant Industry which is under the direction of one of the most distinguished men living, Dr. Vaviloff. He told me that 15 years ago the Institute had 60 Scientific Assistants and a budget of 1 lakh of roubles. To-day the Institute has got about 2,400 Scientific Assistants and a budget of 15 million roubles. They have 400 agricultural farms each of 100 acres where they carry on tests with plants collected from all parts of the world. Not only by means of general education but by means of the Agricultural Department carrying on its propaganda through cinemas and radios, which are the new weapons, they fill the minds of men with ideas. Both in Italy and Russia a large number of agricultural films have been made. I had the privilege of seeing for 10 hours agricultural films in Rome dealing with agricultural and other subjects. So also in Russia where there are Radios in every village. They are nearly as widespread in Italy also, though not quite so much.

I would suggest to Indian economists to study the economics of mind, because, in this country, we have a large mass of men, which, I believe, has capable elements in it. But it is allowed to remain

in a crude condition on account of which the economic development of this country is being largely retarded.

I would like to suggest one other variable in life which has been brought to the surface by this cataclysm in Europe. That is spirit. I was very impressed in Italy by the large-scale and intensive methods of organization used by Government and non-official agencies in regard to agricultural propaganda. A cultured Journalist who was in Rome for 10 years and who watched the growth of the Fascist movement in Italy told me however that the real root of the improvement in Italy was not in this outward organization but it lay in the spiritual background. He said that agriculturists were treated with the respect due to men who rendered an essential service to the community. They were taken to the "Unknown Soldier's" grave and made to pray. Signor Mussolini and members of Government were present when they were given prizes. They were made to feel that they were vital members of the nation and that on them depended the welfare of the nation and that what affected them affected also the nation. He said that it was this feeling which was produced in the minds of the agriculturist, which was even more potent than the administrative propaganda which was done on a large scale and intensively. The idea of bringing spirit into economics may appear somewhat unusual. So let me try to explain it. I think of spirit not merely in its subjective aspect, as something which concerns us individually but as related to the objective world. Supposing I give out a rupee and by a series of transactions a rupee and a half comes back to me. That is an economic activity of a profitable kind and I am, therefore, justified in throwing out a rupee and receiving back Rs. 1-8-0. Supposing that as an organic member of a joint family I gave one rupee and I got back 12 annas, my uncle got another 8 annas and my cousin another 4 annas and the joint family of which my personality formed part got Rs. 1-8-0. I should consider it as an economic transaction of a profitable kind. Supposing similarly that our consciousness extended sufficiently and we all felt that we are vital members of a nation, something like what the Italian farmer felt in relation to the Italian nation, when he spent 2 annas on good seed and the Italian nation got 5 rupees for this amount. His personality had become so extended that the larger self of the nation had become an extension of his own smaller self ; the larger self

received back the result of the economic activity and the circle was complete. So too you can extend the idea, this consciousness being extended as a member of a joint humanity. In all these cases what you think as the spirit is that which takes you away from your smaller self into something higher as a member of a joint family, joint nation, joint humanity or universe. All this is spiritual activity. Supposing you mark on a line a point A, which represents your individual self, a point B, which represents the joint family, a point C, which represents the joint nation and a point D, which represents joint humanity. Then AB is the joint familyself, AC the joint nationself and AD the joint humanityself, as the range of the spiritual life gets wider. The economics based on individual profit is the economics at point A. The economics of AB would represent the economics of a joint family, of AC, the economics of a closely-knit nation and of AD, the economics of a closely-knit humanity. Thus economics becomes more and more spiritual. It is this extension of economic activity that you find in Europe to-day. Each individual has got to put forth a certain amount of effort. If you take the individual self he may get back no return for his effort. But if you take the larger self of the nation, possibly you can see the return. Every country has need for service. Men take to service as something of a sacrifice but service, I feel, is an economic activity. It is not an economic activity when you do something which does not give anybody any return. Supposing some of us went and stood on our heads. It does nobody any good. But if we went and taught somebody it would be a help to a larger group. Service is an economic activity which helps not the individual but his larger self. I feel there is in the new life not merely material that would enable you to re-study the old economics based on land, labour and capital as means of production, but also material that would enable you to extend the sphere of economics and study the economics of mind and the economics of spirit.

We know that in Europe now every country is going in for national self-sufficiency. I think it must be admitted that this is a retrograde step. Humanity has been trying to unite more and more. For four or five years after the war, there was a general consensus of opinion that men should come together and that they should co-ordinate their activities. But since the year 1925, that movement is breaking down.

Every nation is now trying to become self-sufficient. But at the same time, I feel that this national self-sufficiency movement is not an aggressive movement based on selfishness. It appears to be a defensive movement, based on the desire to salvage out of the wreckage whatever is possible. We know that birds when they sense a flood take refuge in high places. We have heard how Noah sensed a flood and built an ark. Perhaps the nations of the world also by their instinct sense a flood that may submerge them and they are building arks into which they are withdrawing their economic life. They deserve more pity than blame.

I feel that as in Physics, about which I spoke before, so also in Economics, new theories may start. The new Physics will, I believe, be idealistic. The new Economics will, I believe, be spiritual. I venture to hope that Indian Economists, with their long training in matters of the spirit, will be able to contribute a virile and helpful share in this construction of the new Economics.

Development of the Irwin Canal Tract

BY

B. Narasimha Iyengar, B.A., Ph.D.

Deputy Director of Agriculture, Mysore State

A brief account of soil conditions in the Irwin Canal area has been published in No. 4, Vol. XI of this *Journal*. A description of the Irwin Canal Farm and its work has appeared in No. 1, Vol. XIII of the same. The present article deals with the development of the tract as a whole.

Now that the channel system is ready to supply water to about 50,000 acres of land on the rotational system of irrigation decided upon by Government, various systems of rotation of crops may be considered. In the natural course of events one-third of the area may go under paddy, another third under the usual dry crops now grown in the tract, and the other third may be devoted to money crops like sugarcane.

Growing of paddy involves levelling of land into terraces of suitable size depending upon the slope of the lands. As such levelling usually brings up a lot of sub-soil to the surface, the fertility of the

land generally suffers to a great extent in the early years of rotation till the soil gets sufficiently weathered. In a good many localities the nature of the land is such that any levelling of even a few inches exposes a sheet of quartz gravel, and until all that gravel is removed and the layer of soil underneath is reached, the terraces cannot be made fit for profitable cultivation. Such an operation may cost over Rs. 100 per acre. On such newly levelled land it is rather difficult to get an yield of 700 or 800 seers or 1,200 to 1,500 lbs. of paddy per acre even with the application of organic and artificial manures, whereas a fairly level bit of good land will easily produce double that crop with the same quantity of manures applied to it. When such land comes under jola or ragi in the next year as a result of the rotational system of irrigation, it may not give a normal yield of crops on account of inadequate weathering and manuring. In the third year of rotation, the land comes under a crop like sugarcane which requires heavy manuring and a large amount of initial outlay not only for seed cane but for the usual cultural operations as well. It is only in cases where the rotational system of irrigation begins with the usual dry crops or sugarcane that a contour system of irrigation can be followed and levelling of the land postponed till paddy has to be grown in the usual course of rotation.

As the cultivation of a long season crop like sugarcane needs a lot of capital and labour, and as the crop cannot be sold as such without being made into jaggery, it is not easy to bring one-third of the irrigated area under such a crop. Even in old well-established irrigated areas such as under the Bannur tank, sugarcane does not occupy more than 15 per cent of it. It then becomes quite necessary to find out some other equally remunerative crops. Crops like plantains and mulberry, though fairly remunerative, occupy the land continuously at least for three years, and consequently such areas have to be left out of the system of rotational irrigation during these periods temporarily. Short season remunerative crops which may be tried in place of sugarcane are gingelly, tobacco, chillies, turmeric, ginger, potatoes, groundnut, cotton, etc. Their cultivation will naturally depend upon prevailing market prices and other conditions.

To work out all problems peculiar to the tract as a consequence of the rotational system of irrigation decided upon, the Irwin Canal

Farm with an area of 600 acres was started in 1931. As the variety of sugarcane ordinarily grown in the tract was a thin and hard variety known as "Cheni," cultivated under the precarious conditions of water supply, and with a view to introduce a good variety into areas to be irrigated from 1932 onwards the farm was started with 10 acres of a good variety of seedling cane H.M. 320 evolved on the Hebbal Farm by the Economic Botanist of the Agricultural Department.

The levy of an import duty on foreign sugar by the Government of India and the decision of the Mysore Government to start a sugar factory in the tract with a crushing capacity of 400 tons of cane per day necessitated a change in the policy of development of the tract, and efforts were concentrated to develop sugarcane cultivation as rapidly as possible to meet the needs of the factory and keep it going for about 200 days in the year.

As the sugar factory was expected to start work early in 1934, arrangements had to be made in 1933 for planting up the required area with cane. Taking an average crop of cane at 25 tons per acre it was found necessary to bring about 3,000 acres under cane. To provide seed material for such a large area, the area of ten acres planted on the Irwin Canal Farm between end of July and middle of August 1931 was cut for seed multiplication from March 1932 onwards and planted on 200 acres of the farm. Thus it was made possible to supply enough seed material to plant up the required area in 1933. As it was considered advantageous to grow a portion of the cane requirements of the factory on its own lands, arrangements were made to grow cane on about 1,000 acres of waste land belonging to Government and coming under crop for the first time. As for the other 2,000 acres of cane, an agreement was entered into with the cultivators in the area to buy up their cane at a fixed price per ton. The price was guaranteed to them just at the time of planting, *i.e.*,fully one year before the crop would be ready for harvest.

Since the cane crop needs a lot of investment and as the means of the cultivators in the area were quite inadequate, arrangements were made to supply them with the necessary seed material and artificial manures on credit to be recovered with interest when the crop was delivered to the factory in 1934. As the indigenous tillage implements were not quite suited for an extensive cultivation of sugarcane reducing manual labour as far as possible, mould-board

ploughs were also supplied to them on credit. The indigenous methods of cane cultivation were only suited for dealing with small areas of less than an acre in extent, and consequently people had to be shown modern methods of cane cultivation. As work on the Irwin Canal Farm was in full swing in 1932, all the operations done there were a sort of demonstration to the people of the tract and contributed in no small measure towards propaganda for bringing a large area under cane in 1933.

The establishment of the sugar factory at Mandya has given a great impetus to cultivation of sugarcane and made it possible to introduce the rotational system of irrigation or the block system of cultivation as it is popularly known. Whereas before, the clamour was all for growing paddy, the rage now is to grow as much cane as possible. The successful growing of cane on the Irwin Canal Farm on waste land, coming under crop for the first time, with the help of contour irrigation and artificial manures and without levelling even one square inch of land was an eye-opener with regard to potentialities of the tract. After the original area of 10 acres was cut for seed, it was ratooned. The ratoon crop came up very well, gave a better yield than plant cane and at less expense due to savings in preparatory cultivation and cost of seed material. The consequence has been to change the view of cultivators to substitute ratoon cane for paddy during the course of rotation. Such a course does away entirely with the necessity of levelling land into paddy terraces at all. So the system of rotation instead of being one of cane, paddy and dry crops gets changed into plant cane, ratoon cane and dry or green manure crops.

As all cane grown in the tract has to be milled at a sugar factory and made into sugar, the capacity of the factory concerned sets a limit to the extent to which cane cultivation can be developed. The recent decision of Government to increase the capacity of the existing factory from 400 to 1,400 tons of cane per day from the crushing season of 1935 makes it possible to extend cane cultivation as well. Taking 25 tons of cane as the average yield per acre for the present, the enlarged factory can deal with an area of about 55 acres per day. With a working season of 200 days the area required will be about 11,000 acres.

This area of about 11,000 acres has to come under cane by rotation in the tract of 50,000 acres already mentioned. Under the triennial system of irrigation, about 17,000 acres can be supplied with water every year for the cultivation of plant cane. In case, people are allowed to take a ratoon crop instead of paddy, then there is a possibility for growing cane in selected places scattered over an area of nearly 34,000 acres.

Experience during the two years of irrigation has shown that under the triennial system based on a rotation of crops or the "Block System," most of the low lying areas in almost every block of land become too moist for cane cultivation when water begins to flow in the irrigation channels generally situated on ridge lines. Such areas of land are naturally to be excluded from the block system and water should be made available for paddy cultivation only, year after year on those lands. For want of proper slope, even a drainage system cannot be laid out to make them dry enough for cane cultivation.

The extent of such lands may not exceed 10 per cent of the area included in irrigation blocks. About 40 per cent of the total area is either stony or too gravelly in nature for a profitable cultivation of cane. The experience of growing cane on the Irwin Canal Farm during the last 3 years has shown that when under a certain system of cultivation and manuring, a deep loamy soil produces 35 to 45 tons of cane per acre, stony and gravelly soils produce only half as much under the same system of cultivation, manuring and irrigation.

If the two classes of soils above described and which make up about 50 per cent of the land under irrigation are excluded from cane cultivation, then the requisite area of 11,000 acres has to be selected out of 17,000 acres, *i.e.*, 50 per cent of the 34,000 acres mentioned above. It is no easy task to distribute the area equitably among all the cultivators who are eager to grow cane and make money to enable them to pay government dues and maintain themselves as well. As a general principle, it may be laid down that the area to be put under cane by each cultivator should bear a certain ratio to the extent of land held by him, the minimum area being one acre for the smallest cultivator.

As the direction of operations of cane cultivation is in the hands of the Sugar Company, it is beyond the scope of this article to go into

details of areas to be planted each month so as to enable the factory to work for 200 days as at present planned. Owing to certain difficulties connected with maintenance of channels, water cannot be made available before 15th January for planting cane. As the one variety of cane now introduced into the area has a tendency to flower in the month of November if planted before April, it may be desirable to restrict cane planting from April to end of August, provided ratooning of cane is allowed next year. In such a case, all cane ratooned between April and August will be ready for harvest from about the beginning of January, *i.e.*, a couple of months after arrowing in November. As it has been found that H.M. 320 cane does not deteriorate even two months after arrowing, cutting such cane from January onwards does not cause any loss to the cultivator.

After having considered at some length the question of growing cane, the other point to be discussed is about crop or crops that can be grown on lands which cannot be brought under cane but which come in the cane blocks of a particular year. Any such alternative crops must bring in enough income to the cultivator to enable him to pay up all dues charged to those lands. Tobacco, gingelly, chillies, potatoes, onions, garlic, turmeric, ginger, groundnuts, cotton, etc., seem to be the probable ones for trial and experiments connected with them are in progress on the Irwin Canal Farm.

When the land comes under paddy rotation, there is not much difficulty in selecting a suitable variety of paddy according to the quality of land on which it is to be grown.

Certain difficulties in working in connection with introduction of the block system of irrigation may be mentioned. From the cultivator's point of view, the ideal method is to allow each man to divide his holding into 3 parts and put each one under a different system of irrigation by rotation. Such a course is not conducive to good growth of crops like sugarcane and dry crops side by side with paddy. The cane crop would suffer due to water logging and a dry crop may not grow at all due to too much water in the soil caused by adjacent plots of cane and paddy. Moreover, it is not easy to watch that the entire holding of a cultivator is not put under paddy or cane alone.

From the point of view of easy control of distribution of water, it would be quite convenient if all lands irrigated by one branch

channel are put under one system of irrigation by rotation. In such a case, distribution of water can be very easily controlled by operating the head sluices. As the area under each sluice differs very widely between 45 and 8,000 acres, suitable units of about 500 or 1,000 acres each may conveniently be formed by grouping land under 2 or more sluices into one unit. In such a case lands under a big sluice commanding more than 500 or 1,000 acres, will have to be suitably grouped into units of convenient size. Such a kind of irrigation necessitates a great hardship on the cultivator. As very few cultivators own lands in villages coming under different branch channels, it will not be possible for a large number of people to take advantage of all the three systems of irrigation in one single season. To be able to do so, they will have to own lands in three different localities which means fragmentation of holding and cultivation as well. Consequently, supervision becomes difficult and a lot of time during working season will be lost in going from place to place with cattle, implements, etc.

Taking all such difficulties into consideration and to give each cultivator a chance to have his holding in more than one sub-plot or " hanta " the maximum area of a sub-plot coming under one kind of irrigation has been fixed at 50 acres. The blocks or plots vary in size from 45 to 450 acres according to lay of the lands. Each plot is sub-divided into 3 or 6 or 9 " hantas " so that the area of any " hanta " does not exceed 50 acres. As every " hanta " comes under a different system of irrigation each year by rotation, 3 contiguous " hantas " may be called an irrigation unit.

As the Irwin Canal tract is an area of precarious rainfall, water is supplied to grow dry crops also successfully by supplementing rainfall by irrigation between June and December. Officers connected with the Lower Bhavani Project in the Madras Presidency and with the Tungabhadra project in the same presidency as well as the Nizam's Dominions recently visited the Irwin Canal tract to get information as to the increase that can be obtained from dry crops by irrigation, it being the object in those areas to exclude sugarcane and paddy from the irrigation scheme altogether. It may safely be said that irrigation of ordinary dry crops ensures a normal crop in years of deficient and badly distributed rainfall. Even the preparation of land for sowing can be done without waiting for rain

which is in itself a great advantage, for, sowing can be done in time soon after a first good shower of rain. If it is possible to grow money crops by supplementing rainfall by irrigation, then water supply to such areas is indeed an advantage. Experiments on suitable crops under such a system are also being conducted on the Irwin Canal Farm.

The Irwin Canal tract has long been a cattle-rearing centre. The introduction of irrigation has deprived the villages of their common pasture land, and individual fields have no longer the wide margins to allow grass growth for fodder purposes. What effect irrigation will have on the live-stock industry remains to be seen. Besides, there is a well-established silk industry also in some portions of the tract. What effect, the increase in atmospheric moisture due to irrigation, is likely to have on the rearing of silkworms is also to be studied in its turn.

The facilities needed for development of the tract may now be considered. So far as sugarcane is concerned the necessary help in the shape of seed, manures, implements and a certain amount of cash advance is being given by the Sugar Company to enable the cultivator to grow cane. In return, the sugar factory is assured of the necessary supply of cane at a price which is fair to the cultivator as well as to the Company.

The other points for consideration in this connection are the necessary permission to enable the cultivator to grow ratoon cane instead of paddy and finding a suitable variety of cane which does not flower if planted before April. Preliminary steps in both these directions have already been taken by Government with regard to ratoon cane and by the Economic Botanist on the Irwin Canal Farm with regard to new and suitable varieties of cane.

As regards paddy, the necessary seed of suitable varieties will be grown on the Irwin Canal Farm and supplied. Similarly, suitable varieties of short-season money crops which may be grown in place of sugarcane will be tried on the Irwin Canal Farm and seed supplied to people in due course.

Last but not least, some organization has to be created to market such crops on a co-operative basis and secure the best possible prices.

In brief, the main lines on which the development of the tract may proceed seem to be as follows :—

1. A rapid extension of cane cultivation to suit the needs of the Sugar Factory.

2. An equitable distribution of the area to be put under cane among cultivators whose lands may come under that crop in any particular year.

3. Development of a rotation of plant cane, ratoon cane, dry or green manure crops on lands which need a lot of levelling, and a normal rotation of cane, paddy and dry crops on other lands.

4. Introduction of short season money crops in place of cane on lands which cannot be put under cane owing to limited capacity of the Sugar Factory.

5. Creating facilities for the cultivation of cocoanut, plantains and mulberry.

6. Formation of honge plantations along subsidiary valley lines for green manure purposes.

7. Formulation of a drainage scheme in areas tending to formation of alkali with a view to mitigate the evil.

8. Measures to maintain the cattle and sheep rearing industry of the tract.

9. Creating facilities for co-operative marketing of crops.

Sugarcane Borers and their Control in the Mysore State

(All the figures are much enlarged.)

J.M.R. T.O.

BY

T. V. Subramaniam, Dip. Agri.

Offg. Entomologist, Department of Agriculture, Mysore State

xxiii, 87

The sugarcane crop in the State is subject to the attack by borers of different kinds from the time of planting. The most important of these may be divided into (1) The "dead heart" borers, and (2) the "central shoot" borers or white borers.

(1) *The "dead heart" Borers.*—These are of two kinds, *viz.*, (*a*) *Argyria sticticraspis*, and (*b*) *Diatraea venosata*. Both kinds are

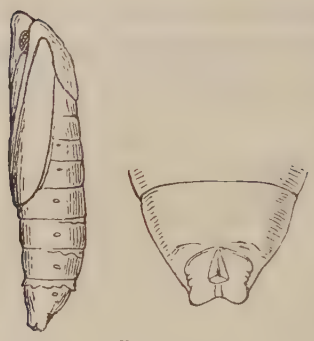
straw coloured in appearance and egg-laying takes place at nights; the eggs are whitish, oval and laid in overlapping clusters; the number of eggs in each cluster ranges from 8 to as many as 60 and are to be

Egg Cluster.

found underneath the leaves of the cane seedlings. Each female moth lays a total of about 400 eggs. The eggs hatch out in about a week and the very active young larvæ soon get scattered about, each larva getting hold of a tender stem of a young growing shoot. The larva cuts a hole in the stem somewhere about the ground level, and slowly eats its way inside the stem. The larva feeds on the soft

Larva.

tissues inside the stem and as a result, the plant sap running up the central shoot is cut off and the latter begins to wilt and becomes completely dry in a few days. If this dry central shoot is pulled off and examined, the portion within the stem will be found to be decayed emitting a foul smell. A number of fly maggots will be found in the decaying portion, but no borer larva. This drying up of the centre shoots of the cane seedlings is popularly known as the " dead heart ". The larva continues to feed on the soft tissues inside the stem making a cavity or tunnel as far as the roots. If there is not enough soft plant tissue available for feeding, the larva leaves the stem and attacks the stem of another shoot. Thus a larva, before it attains its full growth, destroys a number of growing shoots in the early stages of growth of the cane. When the larva is full grown in about 4 weeks, it



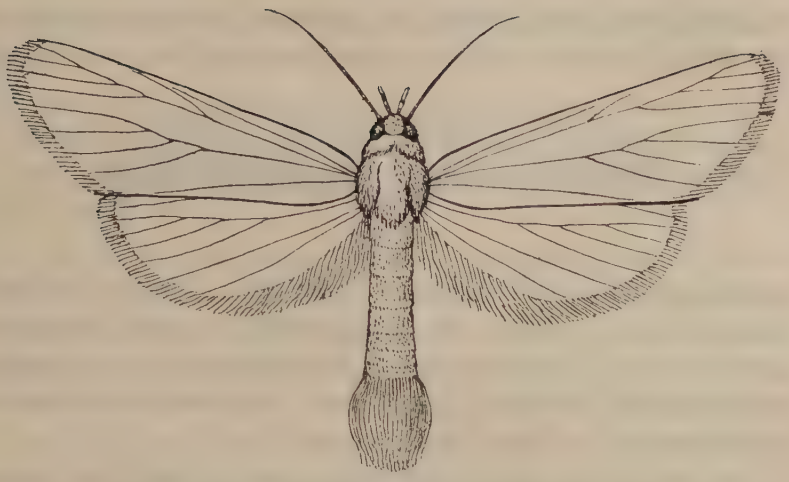
Pupa.

transforms itself into a pupa inside the cavity made by it in the stem while feeding. Before pupating the larva cuts an exit hole on a side of the stem to enable the future winged insect to come out easily. The pupal stage lasts for 10 days after which the moth comes out. Thus in about 6 weeks' time the life cycle of the insect is completed. The life cycle and the nature of the damage to the young cane are similar in the case of the other borer, *Diatraca venosata*, mentioned above but the former kind of insects have been found to be more numerous and the greatest damage is done to the young cane by them.

In addition to the attack of the young canes by these insects grown-up canes are also attacked, but in this case the moths lay eggs on the sheathing leaves of the top shoots and the larvæ hatching out generally attack the eye buds and also the soft top portions of the

The "dead heart" Borer Moth.

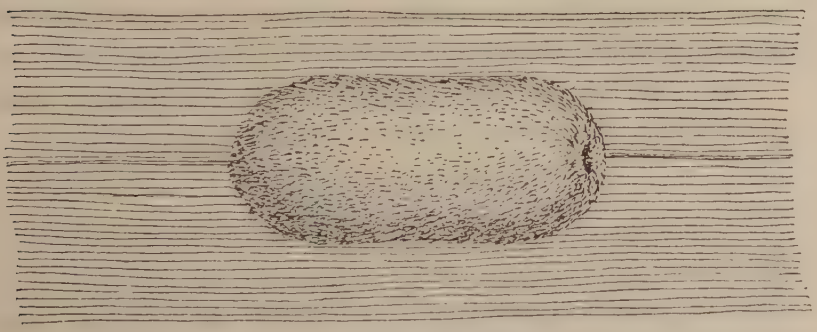
cane. Not much damage has been noticed in such cases excepting when soft varieties of canes are attacked or when the infestation is very severe. The borer infestation of the cane tops can be made out by the presence of fairly big round holes on them. It is through these holes that the moths escape.



The Central Shoot Borer Moth (*White Borer*).

The moths are nocturnal in habit and remain during day time hiding underneath dry leaves and sugarcane trash in the fields.

(2) *The "central shoot" Borers* (The white borers).—These are also of two kinds, *viz.*, *Scirpophaga nivella* and *S. monostigma*. They resemble each other closely except that the moths of the latter have a small black spot in the middle of each of the fore wings. These moths also are nocturnal in habit; they are milk white in colour, and lay eggs on sugarcane leaves in a cluster which is covered with brown hairs, derived from the tuft of the



The Central Shoot Borer Egg Mass.

abdominal end of the female moth. Each cluster contains from 7 to as many as 40 overlapping flattened scaley eggs. The egg clusters are very conspicuous and can be easily made out on the sugarcane leaves. On hatching out from the eggs in about a week the larvæ

are found very active, quickly get distributed and begin feeding on the base of the central rolled up cane leaves and bore through the

Larva.

growing shoot into the stem after a few days. Usually only one borer is found in a shoot. The attack whether on young cane or on grown-up canes is easily made out by the round circular holes on the cane leaves and no typical "dead heart" is noticed in this case as in the case of the "dead heart" borers.

In old canes, the larva, after damaging the growing point, bores down tunnelling into the hard portions of the cane. Its tunnel opens out on a side of the cane and the full grown larva pupates near the

The Central Shoot Borer Pupa.

opening in a silken covering and in 10 days after pupation the moth emerges. As a result of the damage to the growing point in old canes the buds on the sides begin to develop and a bunchy top with a number of long green shoots is formed. Grown-up canes suffer most from the attack of these borers.

As in the case of the "dead heart" borers, the period of development from the egg to the adult is about 6 weeks.

Extent of Damage.

As has been stated above the "dead heart" borers completely destroy the growing shoots of the young cane and one borer larva attacks a number of new shoots or tillerings and destroys them before it completes its development.

A large number of cane tillerings with dried-up central shoots is a common sight in cane fields in the early stages of their growth. Growers are sometimes of the opinion that the dead shoots are replaced by a large number of new shoots and that no serious damage

is therefore caused, but it is to be noted that this is always a set-back in the growth of the canes and at harvest times canes in different stages of maturity are found. In many cases, however, the attack is severe and nearly every tillering is damaged and the blanks in the cane field are numerous sometimes making it necessary to replant the damaged area.

The actual loss in money value per acre due to the borers has not been worked out but it is certainly heavy. Numerous bare patches are caused in the cane fields and the yield of cane per acre is greatly reduced even in cases of moderate attack. In cases of severe attack the patches may become very extensive ; bare areas as large as 4 to 5 acres have even been noticed. Grown-up canes attacked by the white borer, seldom attain full growth which means a considerable reduction in the yield. The stimulation of the growth of side shoots also causes a deterioration in the quality of the juice. The total effect is therefore a greatly diminished outturn of cane and a reduction in the quality.

Through the borer injuries in older canes, a sort of fungus attacks cane tissues and the latter turn to a reddish colour, the juice in the cane turns sour, which leads to a poor quality of jaggery or a reduced outturn of sugar.

Control Measures.

It is strongly recommended that sugarcane cultivators pay particular attention to the following measures of control and include them in their regular routine of sugarcane cultivation to achieve success in keeping down the borer pest :—

(1) *Selection of borer-free setts for Planting.*—There is a general practice among cane growers to use only top portions of cane for planting. These are the only portions sold for seed purposes. Under factory conditions the top portions alone are available for planting. It has been pointed out previously that borers are mostly found in the soft tissue in the top shoots of grown-up or mature canes. Great care should be taken to select only borer-free top setts for planting, as otherwise, the setts planted out with borers form centres of infestation in the newly planted area. In large-scale planting the separation of infested setts from the others may entail a lot of labour and much loss of valuable time. This is overcome by immersing the

setts in cold water for 2 days. It has been proved by experiments that by this treatment borers in different stages of development in the setts are killed. The setts when planted after this treatment are found to sprout quicker and the plants more vigorous than the untreated.

Another method that may be adopted is to completely reject all top setts and plant only the other portions. For this purpose a small area in the cane fields may be reserved and the canes utilized for planting.

(2) *Trash bundle method of trapping the borer moths.*—It has been stated previously that the moths (the parent insects) are active and lay eggs at nights and remain inactive and hidden under dry leaves and cane trash in the fields. After an active period of flight and egg-laying in the young cane fields, the moths make for the nearest shelter as soon as the day dawns. Artificial shelters are provided in the young cane fields in the shape of small bundles of cane trash at the rate of 4 or 5 bundles per acre as soon as the setts sprout. A large number of borer moths are found to take shelter in these trash bundles every morning. The moths are found to be very sluggish and unable to fly. Cooly boys by disturbing the bundles of trash are able to pick and destroy them. The destruction of the parent moths in this manner reduces the possibility of any further egg-laying by these on the cane shoots. One cooly boy is able to examine the trash bundles and destroy the moths in no less than 5 acres of cane every morning and this work should be continued daily for 2 months.

The white borer moths are not attracted to the trash bundles but they are found in numbers resting on the cane leaves. Cooly boys are able to spot these easily, catch and kill them. In addition to the " dead heart " moths, a large number of other moths that are pests of jola, sugarcane, Bengal gram, etc., are also attracted to the trash and are killed by the boys.

In an area of 5 acres of young cane in the Irwin Canal Farm 3,760 " dead heart " borers were caught and destroyed last year from trash bundles by a cooly boy in the course of two months. During this period 2,090 white borer moths and their eggs and a large number of other moth pests of crops were also caught and destroyed.

(3) *Removal of "dead heart" shoots.*—When once the borer pest which can be recognized by the presence of the "dead hearts", has

Old cane showing "bunchy tops" as a result of attack by the Central shoot borer (*White borer*).

Sugarcane top setts showing injury by borer.

Killing of the borer moths hiding under the bundles of sugarcane trash.

started in the fields the shoots with the "dead heart" should be cut off at their base close to the roots, without injuring the side shoots. By this operation the borer larvæ, which remain generally at the base of the shoots, are removed and destroyed and the possibilities of the attack of healthy tillerings by these is removed. It is very important that the cut shoots with the dry cane leaves and other rubbish in the fields are removed in baskets from the fields and burnt. For, these dry shoots, if left in the fields, form centres of attraction to the borer moths and infestation of cane starts from them. The borer larvæ from these shoots get out and begin their attack on fresh cane shoots. By the destruction of the larvæ in the shoots their development into parent moths and a further serious increase of infestation of the canes are prevented.

In the case of very severe early infestation, after cutting off of the "dead hearts" with the borer, it is advisable to give a small dose of some nitrogenous manure to give a good start to the tillerings, so that at harvest, canes of uniform maturity may be obtained for milling.

(4) *Collection of borer egg clusters.*—With a little training cooly boys recognize the egg masses of the "dead heart" borers on the sugarcane leaves and these should be regularly picked out every day. In the case of the top shoot borer (white borer) both the moths and the egg masses are very easy to make out in the fields and can be picked without much trouble.

Parasite of the Borer Egg Masses (*Phanurus beneficiens*).

(5) *Release of the natural enemies of the borer eggs in cane fields.*—In nature the borer egg clusters are parasitised by small wasps, which lay their eggs on the eggs of the borers and prevent their hatching into the destructive borer larvæ, but the larvæ of the wasps rapidly develop into adult wasps on the contents of the borer eggs and fly out in a very short time and search again for eggs of the borer moth on canes in the fields and destroy them in the manner described above.

Many of the clusters of the borer eggs collected in the fields are likely to contain the parasite wasps in various stages of development. As the wasps are the friends of the cultivators, every care should be taken not to destroy the eggs. They should be kept in small tin receptacles with a perforated lid. These receptacles are kept in a small basin of kerosened water. In a very short time—2 or 3 days—the wasps escape through the small holes on the receptacle and fly away; and a number of borer larvæ that emerge from eggs not destroyed by the wasps, crawl out but are unable to cross the kerosened water surrounding the receptacles.

The Agricultural Department in Bangalore has been able to breed one of these wasps, *Trichogramma minutum*—a very minute creature—in large numbers under laboratory conditions. How far

Parasite of the Borer Egg Clusters (*Trichogramma minutum*).

these laboratory raised parasites can be utilized to supplement the natural parasites in the cane fields and other matters connected with the raising and liberation of these parasites on a field scale are being now experimented upon.

(6) *Good cultivation methods.*—Every attention should be paid by cane growers to the proper manuring and irrigation of the young cane fields and the plants should be kept in a vigorous condition and not allowed to suffer for want of irrigation or manure. The plants in a vigorous condition are able to withstand borer attack much better than those in a poor or sickly condition.

SELECTIONS

Topping and Suckering of Tobacco

By C. J. Tregenna, *Tobacco Expert*

The main object of topping and suckering is to hasten maturity. These practices are also important factors in the production of quality leaf.

The natural thing for the tobacco plant to do is to set seed, but by removing the flower head (*i.e.*, topping) as soon as it appears seed setting is prevented and much of the plant food material that would have been used up in seed formation is made available for leaf development. Tobacco plants that are allowed to go to seed or produce suckers have thin papery leaves of poor texture, body and weight.

Topping results in lateral shoots soon making their appearance at the leaf axils and at the base of the plant. Naturally, if these are not removed they also will develop and set seed heads at the expense of the tobacco leaves.

Topping

To determine at what height the plants should be broken off it is essential that the vigour of the plant be first carefully observed, and the earliness and lateness of the season should also be taken into account. Then, too, the question of obtaining uniformity in ripening over a fair area of the crop to facilitate an even and sufficient picking for flue-curing must be considered.

With well-grown and early light and bright types of tobacco it is usual to leave about fourteen or fifteen leaves to come to maturity. With late tobacco it is often advisable to leave only nine or ten leaves, excluding the damaged bottom leaves.

Suckering

It has to be observed that many growers do not fully realize the damage they are doing to their crop in allowing suckers to grow too large. Suckers should be removed as soon as they can be conveniently grasped in the fingers and not permitted to grow longer than 2 inches.

Soil Erosion Losses in Terms of Money

From every conceivable angle erosion is a devastating agency. It is the greatest thief of soil fertility. It steals not only the plant food contained in the soil, but the whole body of the soil, plant food and all.

When this productive material that required centuries in the building is washed out of fields it cannot be economically hauled back, even where it is washed no farther than from the upper to the lower slopes of fields. That which passes down into the beds of streams and on out to the ocean is lost as irretrievably as if consumed by fire. It has been estimated that erosion steals twenty-one times as much plant food as crops take out of the land.

Surveys and soil-loss measurements indicate that at least 3,000,000,000 tons of soil are washed out of the fields and pastures of the United Sates every year. The value of the plant food contained in this amounts to more than two billion dollars, on the basis of the cheapest fertilisers. Of this most inconceivable wastage, the direct loss to the farmers of U.S.A. is not less than 400,000,000 dollars every year. This is paid for in reduced acreage yields, increased cost of cultivation, fertilization and the growing of crops for the sole purpose of building up impoverished fields, in land abandoned, highway's damaged, reservoirs, irrigation ditches and culverts choked with erosional debris, and accumulative thinning of the surface soil, the staggering cost of which is postponed until the last inch of soil is washed off.—These two selections are from *The Agricultural Gazette of New South Wales*, Vol. XLV, Part 2.

Flaked Coffee

In merchandising coffee, three methods are commonly employed in an attempt to give the consumer fresh coffee : (1) roasted whole-bean coffee is ground in the store to the purchaser's orders : (2) freshly roasted coffee is ground and hermetically sealed in exhausted containers, and (3) freshly roasted and ground coffee is packed in a closed but not gas-tight container and sold with an expiration date, beyond which its freshness is not guaranteed. Coffee aroma is a complex mixture of volatile compounds formed by roasting (*pyrolysis*) of the components of the green coffee bean. The soluble non-volatile principles of the bean likewise undergo pyrolyses, resulting in the production of caramel-like substances that give the body to the brew prepared from the roasted coffee. Coffee also contains a fatty oil that undergoes some alteration during roasting. The changes that produce stale coffee are, in decreasing order of importance, volatilization of aroma, oxidation of aroma, and oxidation or rancidity of the coffee oil. During the roasting of coffee, there is a copious production of the gas in which gas that escapes during the roasting, a considerable portion is retained in the roasted bean occlusion. Ground freshly roasted coffee contains approximately five times its volume of this

gas, which slowly escapes as the coffee ages, sweeping out a large proportion of the aroma. When attempts are made to preserve the freshly roasted coffee by immediate hermetic sealing, the accumulating gas produces such a pressure as to rupture the container, unless one of special strength is provided. If, on the other hand, the container is vacuumized, the occluded gas is by no means completely removed during the operation, permitting the building up of some gas pressure within the container, which escapes upon opening, carrying with it at the same time the aroma with which it has become saturated. It has been found that the application of high pressure to ground freshly roasted coffee brings about the expulsion of about 90 per cent of the occluded gas, with practically no loss of aroma. This pressure is most conveniently applied by means of a roller mill. At the same time the coffee particles are converted into thin, flat coherent flakes, averaging about 0.06 inch in diameter and about 0.003 inch in thickness. By this flaking operation the soluble constituents of the coffee become instantly accessible to the extracting liquid, resulting in the quick extraction of all the water-soluble constituents. Coffee thus processed may be hermetically sealed in containers in which the air is replaced by carbon dioxide, and samples have remained fresh for a period of two years. Because of the accessibility of the soluble constituents in these flakes are brewed in a coffee percolator or in a drip coffee pot, the strength of the brew obtained in even less than the customary period of time is such that the amount of coffee required is materially reduced. Flaked coffee yields during brewing operations approximately 50 per cent more extractive than is obtained from the customary drip, and from 75 to 100 per cent more than is had from the ordinary percolator.—(*Ind. & Eng. Chem., News Edition*, Vol. XII, No. 8, 1934, p. 142.) *Tropical Agriculture*, Vol. XI, No. 8.

Derris Root as a Netherlands India Export Product

Substances used for the purpose of killing insect pests may conveniently be classified as (i) inorganic poisons, such as compositions of lead, copper, arsenic, sulphur, selenium; (ii) organic poisons, such as nicotine, thiocyanate, pyrethrum and derris extracts; and (iii) petroleum compounds.

The use of many inorganic poisons, when applied to plants intended for consumption as food, involves risk of poisoning to mankind and animals.

To avoid the absorption of the human system of poisonous insecticide substances, a more direct method is being sought; at present the endeavour is to find insecticides which exercise a more specific action upon the insects and that will present no dangers to man.

However, just as there exists no panacea for all maladies and complaints, so there is no universal insecticide that can fight the very large number of noxious insect varieties in a practical and successful manner; so that the above-mentioned injurious insecticide substances will undoubtedly be retained in their proper places, although it is the intention to limit their use as greatly as possible and substitute for them insecticides not dangerous to the human system.

A good deal of attention has been paid to nicotine which, though a poisonous substance, might be less dangerous than are the inorganic insecticides. But both in the application of this chemical and in the consumption of products on which it is applied, cases of nicotine poisoning have been reported.

Extracts of pyrethrum have been tried, and also different varieties of derris and cube roots, the active principle thereof being rotenone. It has been found that not only are such extracts practically non-poisonous to men and animals, but also that chiefly the extract of derris, or rather the rotenone, is much more destructive to a good many noxious insects than are the inorganic insecticides and nicotine. Poisonous action upon useful insects is but slight, seeing that derris insecticides retain their toxicity, once they have been sprayed upon the plants, for only a short time—which, however, in itself constitutes an objection to its application. To birds these and the pyrethrum compounds are harmless. For human beings rotenone, even in fairly considerable quantities, is without noxious effects. It is for this reason that such combination is employed in fitting exo-parasites of animals, as in cattle dips, and favourable results have also been observed in their effect on endo-parasites. In addition, rotenone can be used with considerable success to keep woollen articles moth-free.

The difficulty that rotenone, under the influence of direct sunlight, rapidly oxidises into inactive derivatives has been counteracted by adding soot to the liquid to be sprayed. But it has been found that dihydrorotenone prepared from rotenone through reduction according to a process analogous to the hardening of fatty substances, has at least the same insecticidal properties as has rotenone itself, and is more resistant to the influence of air and light.

Besides rotenone there are to be found in derris other substances with insecticidal properties, namely, degueline, tephrosine and toxicarol. In some cases, rotenone is a stronger insecticide than is pyrethrum extract, which is its closest competitor.

Originally, an extract of derris root made by means of water and diluted with soapy water, was used as a direct insecticide. On account of the facts that a total extraction of poisonous substances was not

readily affected by this method, that such extracts cannot be kept good without the addition of preservatives and also because the roots vary greatly as regards their poison contents, this method was found to be unreliable. Seeing that the rotenone is very much more poisonous to insects than are the other combinations present in the root, Roark suggested that the rotenone content is the only method by which to judge the value of the roots.

This is all the more important in view of the fact that various firms market not only a total extract from derris root, but also more or less pure rotenone.

Roots that have a content of less than 3 per cent, can be discarded when rotenone is to be prepared. The exporters of the root, whether it be a forest product or an estate-grown product, can demand a higher price if the rotenone content is in excess of the normal. Roark states that if planters will not supply derris root having a guaranteed rotenone content, it is very probable that the consumers will purchase cube roots from Peru and Brazil.

This requirement is especially of importance in the case of Netherlands India product, as it has a somewhat unsatisfactory reputation in this respect. Based on analysis of derris root samples from the forest of Western Java, it is concluded that this bad reputation is, generally speaking, unmerited, or at least unnecessary.

Information is given regarding derris cultivation, selection of stock and age at which the plant should be harvested. Methods of distinguishing good forest-grown derris roots from the useless parts of the plants are indicated. Deliberate substitution of other roots, which may occur in the forest-grown derris, is a reason for preferring the cultivated product.

The article states (on page 388) that in Malaya there is a derris estate at 1,425 metres above sea level. This is inaccurate. Derris is not being grown as an estate crop in Malaya at this elevation. There may be small areas at this elevation, but not an estate.

Mention is made of other plants containing rotenone. At present, however, the only plant of importance besides derris, as a source of rotenone is *Lonchocarpus nicou* or cubé from South America. Commercial samples, 23 in number, which were analysed shewed a rotenone content varying between 0.8 and 11.2 per cent, representing an average of 5.4 per cent and a close relation between the ether extract and the rotenone content. Derris is regarded as of more importance as an insecticide as it contains a higher proportion of other substances that have the same effect as rotenone.

It is considered that the use of rotenone-containing roots for

insecticidal purposes will certainly increase in years to come. The use of pyrethrum is already fairly extensive, but in view of the manner in which derris is advertised and recommended, especially by the Government of the United States of America, its more extensive use may fairly be predicted, to the lesser employment of other insecticides, including perhaps pyrethrum. Also, a combination of derris and pyrethrum seems to result in a very useful insecticide, the application of which may prove to become even more general than that of either separately.

London prices of derris root in 1933 are stated, followed by brief information of packing for export and on sampling for analysis.

As it is very probable that derris, for certain soils and under definite conditions, especially when high-grade clones are planted, opens up possibilities for a paying cultivation, either as a sole or as a mixed cultivation, it will not appear strange that this plant for some time past, has attracted a good deal of interested attention on the part of the various institutions connected with the Department of Economic Affairs in Netherlands India. Endeavours are now being made to obtain high-grade clones that can be used for planting, whilst the investigation of wild varieties and forms is being actively continued so as to assist the exporters of the forest products by supplying them with accurate information, and in order to have available, in as short a period as possible, a considerable quantity of good planting material.

NOTE:—The above Abstract is published in this plate to draw attention to the interest in derris evinced in Netherlands India. At the same time, the Department of Agriculture, Straits Settlements and Federated Malay States, does not necessarily agree with the views on the chemistry of the toxic substances put forward in this article. In particular, it is not yet admitted that there is conclusive evidence showing that rotenone is the most active or most important toxic constituent in derris root. Work on this and on other points is actively in progress in the Department. Naturally, the question of which, precisely, is the most important constituent does not affect the value of the root as a whole.

—(*Editor.*)

The Malayan Agricultural Journal, Vol. XXII, No. 5.

Some Aspects of Soil Erosion

The question of soil erosion has, during the last few months, figured fairly largely before the general public but it is no new problem.

Erosion and loss or wastage of soil have gone on in the country ever since human occupation or cultivation became at all fixed. In the early

times the damage appeared small and the new land available almost endless but with the increase of population and activity the available new areas soon became limited and the losses were forced on notice. There is no doubt that at the present time erosion and loss of soil have reached the stage of becoming a serious menace in the Union. It is a menace that the Government has decided to tackle seriously. A comprehensive scheme has been put forth for collecting information, education of the public, combating the evil by assisting research in the fundamental aspects. It is not at all necessary to go into any details of this national scheme. The press has already contained accounts. It is enough to emphasize that the very existence of such activity on the part of the Government is evidence that the problem is a serious one.

The erosion of soil, except in exceptional cases, only occurs when the vegetation covering the surface is destroyed or interfered with. In uninhabitated regions the surface is remarkably stable. Soil erosion is thus basically a botanical problem.

The soil is the source of water and food materials for plants and also their foothold. The plants which build up the vegetation form the basis on which ultimately the whole continuance of the human race depends.

The soil consists of broken rock material and is penetrated by the roots. These roots keep the soil mass together and increase its mass by penetrating deeper, working into cracks, and so on. In the soil physical and chemical changes go on and organic matter derived mainly from plants, is added, till finally the surface layers become very different both in structure and content from the rocks or rock material from which the soil was originally formed. While the vegetation is untouched and active the formation of soil continues, sometimes rapidly, at others very slowly ; but as soon as the plants are removed or destroyed the loose soil material is exposed to easy removal by wind, water or other agents.

In a country such as South Africa, where practically the whole is liable to extended periods of drought and where so much of the rain when it does come falls in heavy storms, erosion is especially liable to occur. The heavy rain falling on dry soil wets and loosens the surface and runs downhill. Unless the soil is held firmly by roots the sudden downhill movement of large quantities of water is liable to remove whole sheets from the surface. In other cases where the water runs off in channels, dongas, which may attain considerable depth, are cut out. These dongas cause great wastage of soil and themselves are a source of drying out of surrounding soil that often results in the death of plants and hence further wastage.

It is not proposed in the present note to attempt any sort of general account of the position in regard to soil erosion in the country but rather to treat very shortly some of the special aspects present in the South-Western Cape region. This region differs in many ways from the remainder of the Union and in any scheme covering the whole country is apt to have its own problems treated as of minor importance in accordance with its proportion of area to the whole. For this reason these local problems are brought forward.

The South-Western Cape is characterized by the rainfall being wholly or in very large part confined to winter months and the summer dry. Correlated with this climate the vegetation is very characteristic, being typically bushy, not very tall, and generally with hard evergreen leaves predominantly of small size. Grasses and any turf-forming plants are infrequent or absent and hence grazing is not carried on to any large extent. The main agricultural value of the region is fruit growing and grain production. The country is mountainous and the land of agricultural value is confined to the lower slopes and valleys and the coastal plain. In this region the losses due to soil erosion are less obvious than in many other parts but are none the less severe.

Erosion is worst on the mountains and as these are of little agricultural value, the loss has, up to the present, been either totally neglected or treated as of no serious account. It is true that the mountain vegetation, which is composed of bushes and reeds, is of little value as food for animals, and the soils too steep, too shallow and often too poor to justify cultivation. In an attempt to create pasturage the practice of burning the vegetation has gone on for centuries. Burning was carried out even before the advent of the white man, who has continued the habit. Several reasons are brought forward in support of the practice. The untouched bush is thick and most of the plants hard and woody. Animals find little to feed on and in the old days were liable to attack from easily concealed leopards or natives. When the bush is burned a certain number of the plants sprout up from underground portions that survive and the young soft shoots are much more palatable than the old hard ones. The apparent improvement is, however, of short duration. After two to four years, depending on local conditions, a dry bush cover, generally of low stature, is established. Not at all infrequently this re-established bush is again burnt in the hope of getting further improvement. But such recurrent fires, especially when combined with grazing, soon eliminate all but tough resistant plants of no economic value at all.

Fire destruction has other effects as well, effects that may mean serious ultimate loss. Fires most commonly occur in summer and especially towards the end of the dry season when both bush and soil are dry. After the fire the soil, which may have been much heated, is exposed to the full drying effect of the sun and wind. This alone causes rapid alteration and often total disappearance of the organic matter in the soil which seriously reduces its nutritive value for plants and its capacity to hold water. The pale colour of the soils of recently burnt areas must be familiar. Under thick bush the surface layers of the soil are dark, often black, while after a fire the colour changes to white or very pale. This impoverishment of the soil by loss of organic matter renders the reappearance of the plants slower and more difficult.

The unprotected soil of a burnt area is exposed to erosion by wind or water. In the dry season winds remove the loose dry soils, especially in the upper portions of the mountains. When soil in large quantity becomes open to movement by wind action the establishment of plants may become very slow or even impossible.

Water in the form of rain is still more potent as an agent for erosion. The soil, no longer held by roots, is washed down the slopes which may become so denuded that the solid rock alone remains: a condition too often seen on our mountains and especially in those with the heaviest rainfall.

After burning the vegetation is regenerated but the vigour of the new growth, its character, and the time taken for it to be formed, depend on the local conditions and the amount of erosion. Even under favourable conditions, when little soil removal occurs, the destruction has an adverse effect. One example must suffice taken from an area that has been under observation for a number of years. This was on a granite soil on the slopes of Table Mountain. The angle of slope was not sufficient to allow of serious erosion. Before the fire the soil was covered by a dense growth of bushes beneath which were a number of shade tolerant species. Ninety-three different species were recorded of which fifty-one were woody plants. After the fire thirteen of these sprouted from still living underground portions: the remainder either restarted from seed or were totally destroyed. The area was kept under observation for seven years, during which time no further fire took place. At the end of the period the vegetation, as compared with the original, was lower and less dense. It contained a larger proportion of low growing woody plants with small leaves. The shade enduring plants, which have relatively large leaves, had mostly disappeared. The whole aspect was drier and less luxuriant: from the point of view of pasturage it was certainly less desirable.

This example was under favourable conditions. When these are less good the changes towards increased dryness are more pronounced and the time that elapses before regrowth is complete is extended. Very frequently fires occur before re-establishment and each fire has an increasingly deleterious effects, so that after very frequent fires the vegetation becomes sparse and is largely made up of reeds, low bushes or bulbous plants which have no feeding value for animals and very little holding power on the soil and which produce very little soil improvement. The whole upper portions of many of our mountains are now in this condition though the general type of climate and moisture lead one to expect an especially vigorous vegetation. Fires followed by erosion by rain and wind have resulted in so great a removal of soil that only the most resistant plants which make little demand are able to survive.

People can and do say in this connection,—"Why bother about the mountains which are of no value as land; let us concentrate on the fertile low grounds." This is a very short-sighted view. The condition on the mountains has a decided influence on the slopes and valleys at the base; an influence shown in more than one way. The most important is on the water supplies, especially on springs and streams. Even the vegetation is undisturbed and the soil well penetrated by roots and containing organic matter, the rain water penetrates. In part it is held, in part it percolates down and escapes in springs and streams. The percolation is gradual and the soil protected from loss of evaporation and hence the streams continue to flow evenly. On the other hand, when the vegetation is destroyed by fire the rains either remove the unheld soil or compact it. In either case the water runs off at once and little or none is held. The streams come down in flood but continue flowing for a short time only. Floods are very liable to occur in the low lands and the rush of water from above in addition to the ordinary rainfall causes dongas or other forms of erosion. Also in the sparse vegetation following fire such water as is kept in the soil is liable to be lost by evaporation.

Destruction of the vegetation has another serious effect on water supplies. The mountains here are frequently covered by mists brought up by the South-East winds in summer. These clouds condense on the plants but only to a negligible extent on the soil itself or on the rocks. The late Dr. Marloth demonstrated some years ago that the condensation by bushes and reeds might reach an amount corresponding to several inches of rain. In unburned vegetation this reaches the soil and helps to keep streams running. When the vegetation is burnt it is wholly lost. As the whole country is dependent on the mountains for its water supply it would seem obvious that a preservation of the vegetation on them is

both urgent and essential.—*The Tropical Agriculturist*, Vol. LXXXII, No. 4.

Breeding for Immunity

By L. N. H. Larter, *Geneticist*

Up to the commencement of the present decade control of disease in agricultural crops followed similar lines to those employed in the treatment of animal disease, but in these days, the narrow margin between cost of production and marketable value has rendered the measures designed by the plant pathologist in many cases prohibitive to the practical man. Consequently there is an increasing demand for crop varieties which are resistant or immune to the more serious diseases and pests. Agriculturists have previously selected their commercial varieties on the basis of increasing quantity and improving quality of the product both of which appear to be fundamentally antagonistic to disease resistance which has therefore tended to decrease : it is only when the inevitable epidemic has decimated a crop that the need for that characteristic is fully realized. Just as with plants, the reduction of mortality due to advances of medical science will tend to select a race of people of decreasing natural resistance to human diseases. That agriculture has hitherto not progressed more rapidly in the invention and adoption of resistant varieties has been largely due to the lack of investigators conversant at the same time, both with the technique of plant breeding and with that of plant pathology. Consequently, in the past, confusion has arisen over many so-called diseases. Some forms of dwarfing in Maize, and albinism in many plants which since the encroachment of genetics into the field of plant pathology have been shown to be inherited characteristics of certain strains, are not therefore amenable to the usual curative treatments.

Diseases such as the rusts, in which the relation between the parasite and host are finely balanced, lend themselves to treatment by this method with much greater readiness than those in which the parasite shows less specialization, *e.g.*, the Downy Mildews and *Rosellinia* root rots, but in all cases breeding is facilitated by a knowledge of what exactly constitutes disease resistance.

In the first place, resistance is uncorrelated with vigour, more usually the most robust plant is the most susceptible ; furthermore varieties which prove completely susceptible under laboratory conditions often appear highly resistant in the field. Thus in temperate climates early varieties of Irish Potato prove resistant to Late Blight (*Phytophthora*

infestans) in the field on account of the fact that the annual onset of the disease does not occur until the early varieties are nearly mature. But by artificial infection or late planting these same varieties may be proved highly susceptible. Thus early varieties in this case are resistant on account of their capacity for *avoidance* of the disease. True resistance, however, may be due to a number of causes, physical, chemical, etc. Some forms of wheat, for instance, are resistant to certain fungus diseases on account of the waxy bloom on their surfaces precluding the formation of the film of water necessary for the preliminary growth of the fungus prior to its penetration of the host tissues. Resistance due to chemical causes is found in relation to the disease of Onions known as Smudge (*Colletotrichum circinans*). In this case varieties with red pigment in the bulb are immune whilst the white and yellow forms are susceptible, and it has been shown that the red pigment is toxic to the fungus. Another interesting case is that of Rust resistance in Wheat, in which resistant varieties are actually hypersensitive. The initial attack of the rust causes death of the wheat tissues and failure of the establishment of the disease, for the rusts are highly specialized parasites and will only live in healthy tissues of the host plant. Knowledge of this kind with respect to the disease indicates to the breeder the most profitable lines along which to work.

In some cases, as with Wart Disease (*Synchytrium endobioticum*) of Irish Potatoes commercial varieties may be found already resistant to the disease and can be grown for profit without further improvement. Direct selection often plays an important part in the acquisition of new resistant forms. The aftermath of an epidemic in a field may reveal a few individual plants which have withstood attack. In this way were found strains of "White Burley" resistant to Root Rot (*Thielavia basicola*) of Tobacco which proved in no way inferior in quality to the general stock. More frequently, however, such resistant strains are commercially inferior and call for improvement by breeding. In this way varieties of tobacco immune to Mildew (*Phytophthora nicotianæ*) have been built up. In most cases agriculture has developed strains of plants which lack the disease resistance usually found in their wild prototypes, so it becomes necessary by interbreeding wild and cultivated forms to rebuild a commercial variety. New varieties so synthesized have gone even further and show definite improvements on the current types. Breeding for immunity in this way when we have to revert to the wild type to find immunity, has the disadvantage of introducing undesirable wild characters into the new form. This has been a serious handicap in the efforts to produce Grape vines immune to the

mildews, *Plasmopara viticola* and *Uncinula necator* and to *Phylloxera* attack. The American vines, *Vitis riparia* and *Vitis labrusca* proved immune, but the progeny from crosses with the cultivated type *Vitis vinifera*, though resistant, all showed a deterioration of flavour, and resistance to *Phylloxera* has so far only been achieved by grafting "vinicola" scions on to resistant seedling stocks. More success has recently been obtained in Hawaii in breeding Pineapples resistant to Eel Worm (*Heterodera radicicola*). It has there been found that varieties with a well developed fibrous root system show resistance. The Cayenne, a popular commercial type, has relatively few fibrous roots and is highly susceptible. It was therefore crossed with a wild Brazilian form with abundant roots and the progeny were backcrosses to the Cayenne. From the resultant seedlings a type was selected which proved to have the desirable commercial characters of the Cayenne as well as a high degree of resistance to Eel Worm attack.

Immunity to Tomato Leaf Mold (*Cladpsporium fulvum*), a disease common in Jamaica, but most serious where the crop is grown under glass was provided by the wild species *Solanum racimigerum*. This crossed with commercial tomatoes gave a progeny all of which were immune, though inferior in quality. This, however, was restored by backcrossing to the tomato and selecting the immune types from the resulting seedlings. This represents probably the simplest case to deal with, in which immunity is completely dominant to susceptibility and is inherited as a single factor. In other cases inheritance of immunity is more obscure. *Solanum demissum* is immune to Late Blight of the Irish Potato, *Solanum tuberosum* but when crossed with susceptible varieties the offspring contains forms both immune and susceptible to the disease. Here there are probably two or more hereditary factors acting as determinants of immunity. Probably the most complex case is that of the cereal Rusts, *e.g.*, Black Stem Rust of Wheat due to *Puccinia graminis*. This disease is caused by a multiplicity of strains of the one species, and it is impossible to produce one variety of wheat resistant to all the strains. A stock of seed is built up by mass selection from a number of the more resistant wheat forms and such a stock will give a crop which, though presenting a general resistance to the Rust, can never be completely immune.

The economic value of this method of combating plant disease needs no emphasis when it is realized that but for the new varieties of coffee produced by crossing *Coffea arabica* with *Coffea liberica*, the industry in Java would have suffered the same fate at the hands of Leaf Rust (*Hemileia vastatrix*) as did that in Ceylon. Again in Java, in 1880,

the Cane industry was threatened by the virus diseases, Mosaic and Sereh. The variety known as Chunne in North India (*Saccharum spontaneum*) was found to be highly resistant and after laborious efforts in perfecting a technique to overcome the many difficulties encountered, success was obtained in crossing this with the cultivated canes, *Saccharum officinarum*. The F1 generation, the progeny of this cross, was back-crossed to the cultivated varieties, and by repeating this process, known as ennobling, the great diversity of seedling canes at present available has been obtained. Furthermore, noteworthy improvements have been made on the original forms as regards yield, sugar content and other significant properties of the crop. There has been produced by similar means in the Sudan the variety of Cotton, Sakha 4, which is both superior to the Sakel strains from which it arose, as well as resistant to Cotton Wilt (*Fusarium vasinfectum*). Cotton presents one of the few cases in which breeding has been effective in controlling insect attack. Dr. Harland in Trinidad has produced a true breeding strain which is both immune to the attacks of the Leaf Blister Mite, *Eriophyes gossypii*, as well as resistant to the Black Scale Insect, *Saissetia nigra*.

Self-fertilized annuals constitute the majority of the crops so far dealt with; for annuals lend themselves most readily to breeding, and self-fertilization facilitates the production of pure lines, or true breeding strains. Only in very recent years has work been commenced with perennials such as forest crops. In temperate climates a start has been made at improving the forest trees, firs, elms, etc., and in the tropics such crops as Rubber, Cocoanuts and Citrus have recently attracted the attention of geneticists. Unfortunately in the case of tree crops from which the fruit is harvested, as the cocoanut, the time interval involved between successive generations renders the work unprofitable to the individual and can only be successfully pursued by more permanent institutions. The incidence of Wither Tip (*Gloeosporium limetticolum*) on the West Indian Lime in Trinidad in 1917, which rapidly became epidemic, and its subsequent spread to the neighbouring islands, stimulated a search for a resistant strain. Such was found among a batch imported from the Philippine Islands but was greatly inferior in quality to the West Indian Lime. This crossed with the West Indian Lime gave, from the sexually produced seed a very variable progeny, some being susceptible and some resistant to Wither Tip; but many show an improvement in acid content and oil quality and one at least has distinct commercial possibilities. It is probable, therefore, that the tree crops will prove responsive to the same breeding treatment, which, by circumventing the ravages of disease, has been repeatedly effective in the salvation of many of the short-term

crops.—*The Journal of the Jamaica Agricultural Society*, Vol. XXXVII, No. 9.

Vernalization: A New Method of Shortening the Vegetative Period of Plants

By N. Von Gescher

The first workers who studied intensively the influence of light on the flowering of plants attributed the greatest importance to the *intensity* and the *quality* of the light. Later, particularly as a result of the work of Garner and Allard, from 1920, the fundamental influence came to be recognized of the *relative duration* of the day and night on the plant development, which phenomenon they termed "photoperiodism". According to these writers the periodicity of light exercises a fundamental influence on the rhythm of plant growth. Plants are adapted to this periodicity, which differs greatly with latitude.

Short-day plants, having an optimum reproductive development with a day length of 14 hours at most, may be distinguished from long-day plants, having their optimum with a day length exceeding 14 hours, while there is an intermediate group of plants independent of periodicity of light. To the group of short-day plants belong in general all those of tropical origin (cotton, soya bean, maize, millet), while all the cultivated plants of more or less northern origin are long-day plants, such as wheat, rye, oats, flax, etc. The correlation between the photoperiodic behaviour and the region of origin is so close that it would seem possible to deduce the latitude of origin of plant from its photoperiodic reaction.

Light is only one of the factors responsible for plant development. There are other factors which have a profound influence on the succession of the various phases of development, and more especially, on the transition to the fruiting stage.

In 1903 Klebs had already shown that the development of the reproductive organs results from quantitative changes in the general and external factors regulating the development of the plant. According to him there are not specific external factors having a constitutive influence. The factors which decide vegetative growth and reproductive development are identical, but it is their intensity and reciprocal ratio which decide which form of development shall occur. According to Klebs the factors giving rise to flowering are an increase in carbon assimilation under the influence of light and a reduction of the concentration of certain salts, particularly nitrogenous salts, in the soil. A certain proportion between the carbohydrates and nitrogen predisposes

the plant to flowering. Tinker (1929) and Rasumov (1930) have carried our knowledge further with regard to the factors governing flowering and have proved that a certain periodicity of lighting applied to plants may give them a tendency to flower without, however, the tendency being manifested immediately.

It is here that the ideals of Prof. Lyssenko, of the Ukrainian Institute of Plant Breeding at Odessa, enter the field. What applies to light applies also to other factors influencing the rhythm of plant development. Lyssenko has in fact proved that the factors necessary for transition from the vegetative stage to the reproductive stage are not bound to any particular moment. Their influence may come into force at any moment in the development of the plant. The seed itself at the first incidence of germination is capable of receiving this influence, the effects of which will make themselves felt in the course of growth. Lyssenko follows the ideas of Klebs by making a clear distinction between *growth*, namely, increase in weight and size of the plant, and *development*, which is the transition of the plant to the successive stages,in other words, a *qualitative* change in the nature of the plant. He has developed the theory that the entry of the plant into a new phase depends on a complex of well-defined factors, no one of which must be lacking. In general it is the reproductive phase which is of interest to the farmer. In any particular area only those plants or varieties of plants are cultivated whose vegetative period is such that they are able to complete their reproductive phase in the local conditions of climate.

If it were possible to influence artificially the external factors, that is to say, the sum total of the factors determining the development of a given plant, and more particularly its transition from the vegetative to the reproductive stage, it would be possible to cultivate this plant in regions entirely different from those which are natural to it. This is one of the objects of Lyssenko's work.

He endeavoured first to ascertain these factors accurately. It soon became apparent that they differ in the case of different species and even different varieties of plants. It goes without saying that the conditions for short-day plants must differ entirely from those for long-day plants. To enter into their reproductive phase all plants of tropical origin require a combination of high temperature and short daily period of light.

It is particularly with regard to the nature of the influence of light that the researches of Lyssenko and his co-workers have introduced new knowledge, which if it is confirmed will change the conception of photoperiodism of the numerous workers, American and Russian in

particular, who are concerned with this phenomenon. Lyssenko, in fact, has been able to prove that these influences on flowering are exerted by light and darkness themselves and not necessarily by an alternation of the two. If it is necessary for a plant to pass through a period of darkness, it is sufficient for this period to be passed through in the seed during the earliest stages of germination. When the stages which require darkness are passed the plant obtained from such treated seed can be grown even under constant illumination: hence neither long- nor short-day plants require photoperiodism. For growth and development of short-day plants light and darkness, but not the alternation of short-day and long-night, are necessary.

It is on these ideas based on a long series of experiments that Lyssenko has established the process termed "iarovisation" or "vernalization"*. This consists in regulating the length of the vegetative period of a plant by artificially adapting it to a given environment by means of the combined action of temperature and light on the first phase of the growth of the plant, that is to say, on the germinating seed.

The practical interest of vernalization consists at present in accelerating the fruiting season, thus making plants earlier in maturing. It thus allows of growing a spring-sown crop instead of a winter crop. By curtailing the vegetative period it is possible to extend the cultivation of wheat, cotton, soya bean and other plants into regions in which their cultivation had previously been impossible. The process may also be of fundamental importance in the combat of drought, by bringing the plants to maturity before the arrival of the summer drought. Plant breeders who are always anxious to cultivate as many generations as possible in the course of a single year, will be able to draw considerable benefit from it: further, since any factor which increases the earliness of harvest increases also the content in protein, vernalization will exercise also this very desirable effect from the standpoint of the baking quality of wheat.

With a view to encourage those interested to test these results for themselves, Lyssenko's process of vernalization of wheat will be described. Wheat requires to reach the fruiting stage a period of low temperature and long illumination. Spring wheat, for example, requires a temperature of 3 to 5°C. during 10 to 15 days. It will thus be necessary for these conditions, artificially produced, to exercise their influence on the germinating grain in order to give it the tendency to pass earlier from

* For the etymological explanation of this term see the *Monthly Bulletin of Agricultural Science and Practice*, 1932, No. 8, p. 289.

the vegetative to the reproductive phase. That is to say to make it earlier maturing.

The grain is first soaked with water to 15% of its weight : 100 kg. of wheat containing 13 to 15% of water will absorb 33 litres. This water is added in three applications. To absorb the first application about two hours are required, for the second 5 to 7 hours, and the third will be absorbed still more slowly. The grain must be turned with shovels to ensure the water being well mixed and to prevent the temperature rising above 15°C., the optimum temperature being from 10 to 15°C. When 3 to 5% of the grain has begun to sprout, which takes about 24 hours, the preparation is finished and the chilling process of vernalization proper begins. The temperature is lowered to 3 to 5°C. and kept at this level day and night for 12 to 15 days. The interior and exterior temperatures of the layer of grain must be accurately controlled. After the treatment the grain must be dried by shovelling and winnowing.

Autumn wheat is vernalized at a temperature of 0 to 3°C. during 40 to 55 days. It is scarcely necessary to emphasize that during such treatment care must be taken to aviod mould. Experiments are in progress to obtain control of mould by chemical disinfection.

The process of vernalization elaborated by Lyssenko for cotton is extremely simple and consists only in increasing the temperature of the seed by self-heating to 30°. For soya bean the following method is proposed : soaking with water at the rate of 75 litres to 100 kg. of seeds, vernalization for 10 to 15 days at a temperature of 20 to 25°C. in the absence of light.

Vernalization of potatoes is effected by threading the tubers on wire and exposing them to continuous light for 20 to 30 days at 15 to 20°C. in a dry atmosphere.

It is interesting to draw a parallel between the work of Lyssenko and the recently published studies of G. Tallarico in Italy. In the course of his numerous experiments aiming at physiologically influencing seeds to increase the yield, Tallarico submitted hard wheat for 14 days to the influence of a temperature of 2°C. before sowing. This experiment, which was carried out at two different places during two consecutive years and repeated in three replications, gave the following averages :— on the control plots, 16.9 quintals per hectare ; for the plots with treated seeds 19.6 quintals per hectare ; or a gain of 2.7 quintals per hectare. It should be expressly stated that Tallarico, though independently approaching, as regards temperature and the duration of the period of treatment, the prescriptions for Lyssenko's vernalization, differs undamentally in the fact that the seeds were treated in the *dormant*

stage, whereas Lyssenko on the contrary treats seed after germination has already begun. Also Tallarico mentions particularly that the effect of treatment by cold does not affect the vegetative period, but only the yield. In the vegetative cycle of plants the period of germination constitutes a critical stage, a period of instability and special sensitiveness to external factors. It is for this reason that during this period plants are particularly susceptible to artificial influences. In a further series of important experiments Tallarico stimulated seeds by a treatment with water without however repeating treatment with the low temperature. As did Lyssenko he uses as little water as possible to obtain complete imbibition, which is checked at the moment when the first sign of germination is apparent. His numerous experiments have given the following average yields:—

	In Poor Soil.	In Rich Soil.
Untreated Seeds (=100)	100	100
Seeds treated with Water	130	106

Thus there is observed a great increase in the crop as a result of treatment with water. This increase, however, depends to a large extent on the quality of the soil, as has been often observed in the experiments of stimulation by Popoff method. A comparison of the experiments of Lyssenko with those of Tallarico is very instructive. If treatment with water and treatment with low temperature each exercises a stimulating influence, and if on the other hand the effect of this stimulation depends on the nature of the soil, it is clearly demonstrated that the effect of vernalization may be due to reasons very diverse and independent of each other. This shows also the complexity of the phenomenon and the difficulty of analysing it.

Since the original works of Klebs on the subject it has been recognized that the factors affecting plant development act indirectly through their influence on the enzymes. Demkovsky, one of Lyssenko's co-workers, has carried out exhaustive studies with a view to finding a biochemical explanation of vernalization. According to him enzyme activity increases gradually, and differently for the various enzymes during vernalization. The explanation of the phenomenon does not, however, become simple if the complex problem of enzymes is taken into consideration. The effect of vernalization of wheat may, however, be explained in the following manner: the preparation for vernalization (soaking at 10°) activates the enzymes thus increasing the sugar content: the vernalization proper which follows and consists in reducing the temperature to 2°, reduces respiration and thus leads to a concentration of sugar which predisposes

the plant (in this case the germinating seeds) to flower. The factor "darkness" does not come into play, as in the case of short-day plants, because wheat, which is a long-day plant, is adapted to the periodicity of light occurring in northern regions. A similar explanation of vernalization may be made for short-day plants. This however is only a matter of unproved theory.

It would appear that varieties coming from distant countries are liable to react most strongly to vernalization and that the local varieties are less susceptible to its influence. In this case vernalization should serve to replace by an artificial process natural adaptation to external condition. It does not seem probable, however, that changing one or two factors such as light and heat, could suffice to ensure complete adaptation of the vernalized plant to environmental conditions differing profoundly from the normal conditions. It would thus appear unwise to try to use for vernalization and larger scale cultivation foreign non-acclimatised varieties.

Studies of vernalization have been carried out in Russia on a huge scale. It will suffice to mention here that in 1932 they had already been extended to the 7,000 varieties of wheat constituting the international collection of the Pan Union Institute of Plant Breeding. Thousands of varieties of this collection had not been able to come into fruit in the regions where the experiments were carried out, or else fruited too late and produced stunted grain: sown after vernalization the same varieties proved earlier than the local varieties. Experiments carried out in 1932 on the collective Farms ("kolkhoz") and the State Farms ("sovkhoz") over an area of 43,000 hectares gave for the most part favourable results, consisting in an increase in yield of one quintal per hectare*.

Satisfactory results have also been given by the experiments with cotton. Those made in Ukraine, in Northern Caucasia and in

---

* Note.—The following are some recent details of the results of these experiments and of certain others:—

1. In the spring of 1932 at Kharkov, Ukraine, 1,427 varieties of wheat from Aserbeidjan (Trans-caucasia) were sown, vernalized and non-vernalized. On 5th July all the plots sown with vernalized seed had headed, whereas the control non-vernalized plots were still behindhand; in fact, at this date only 198 of the 1,427 varieties (or 13.8%) had come into ear; heading increased until 6th August, when 649 varieties had headed; but the 778 other varieties never headed at all.

2. In 1932, also in the Ukraine, in 240 kolkhoz and 12 sovkhoz a total of 3,334 hectares were sown with vernalized seed. The gains in yield per hectare attributable to vernalization were as follows:—1 quintal in 127 kolkhoz, 2 quintals on 38 kolkhoz, 2.3 quintals in 9 sovkhoz and 3 to 9 quintals in 18 kolkhoz.

Trans-caucasia, have shown that vernalized cotton has an accelerated flowering and maturation.

In consequence of these favourable results the U.S.S.R. National Commissariat of Agriculture, in agreement with the Directors of the regional agricultural administrations and the National Commissary of the Federated Republics, decided at the meeting of 12th October 1932 to sow vernalized seed, using primarily hard wheat, in the spring of 1933 over an area of 200,000 hectares, 100,000 of which were to be in Ukraine. The Ukrainian Institute for Plant Breeding gives advice on the varieties suitable for vernalization. Vernalized cotton is to be tested on an acreage of 3,000 hectares, of which 2,000 are in regions where cotton growing has been recently introduced. The Ukrainian Institute has been made responsible for sowing in various parts of the Soviet Union, including the extreme north, the international collection of vernalized varieties of wheat, oats, barley and bean which are available at the Leningrad Institute for Plant Breeding. The Odessa Institute has received thousands of enquiries concerning vernalization. Upwards of 25,000 explanatory notices about vernalization of wheat have been distributed and have been insufficient to meet the demand.

All this proves the importance attached in Russia to vernalization. In fact, if all the hopes founded on it were vain and the only result remaining were the possibility of accelerating by 4 or 5 days the maturity of wheat, this alone would be sufficient to render vernalization of interest for a number of countries. In the light of the very numerous experiments carried out in Russia during 1932 it would seem certain that this end will at least be obtained. It is much to be regretted that the directions for vernalization were at first published only in Russian and Ukrainian and in not readily accessible publications, so that for a long time they

---

In 25 farms however vernalization produced no increase in the yield and in 35 farms it even reduced the crop, a failure which is attributed to the use of unsuitable varieties and to a defective application of the technique of vernalization.

3. In the organ of the U.S.S.R. National Commissariat of Agriculture, 29th September 1933, were published the encouraging results given by vernalization in the region of the middle Volga where in 1933, 28,000 hectares were sown with vernalized seed; this year the early drought damaged particularly the non-vernalized wheat which thus gave a lower yield than the vernalized wheat.

4. In a preliminary note published in *Scientific Agriculture*, Vol. XIII, No. 11, 1933, F. Greller and his co-workers of the Central Experiment Farm of Ottawa, Canada, state that vernalization of cereals has in 1933 produced results similar to those obtained by Prof. Lyssenko.

escaped the attention of the world. The consequence is that up to the present it has not been possible to test the Russian results in other countries. The example of seed stimulation which caused such a stir a few years back and proved of very small practical interest, should make us wary of too greatly exaggerated hopes. However, the problem is sufficiently promising from practical and scientific points of view to deserve exhaustive and immediate trial.

It is to be hoped that the results of the important Russian experiments and of the control experiments now in progress in other countries, will enable vernalization to pass from the experimental field into general practice. It may then prove that vernalization is one of the most valuable of the technical inventions in the domain of agriculture of the last twenty years.—*International Review of Agriculture*, Year XXIV, No. 10.

Flowering, Pollination and Natural Crossing in Rice

By W. Poggendorff, B.Sc. (Agr.)

Assistant Plant Breeder

The following article presents in outline the results of some five years' observations made during the course of improvement work with rice in the departmental stud plots at Yanco, in the Murrumbidgee Irrigation Area, and briefly compares these with similar observations made in other rice-growing countries. Literature dealing with rice is remarkable for the diversity of opinion expressed by workers with this crop on such aspects as time of flowering, relationship between glume dehiscence and pollination, extent of natural crossing, etc. Jones, in his review of this literature, ascribes the varying behaviour of rice in different parts of the world to varying local conditions, and to varietal peculiarities. It may therefore be of interest to report observations made under growing conditions which, in one respect at least, are apparently unique.

One of the principal objectives of the observations at Yanco has been to determine the precise conditions under which artificial hybridisation could be effected with maximum success. The varieties chiefly used were Caloro, Colusa, Carolina Gold, Carolina White, and Lady Wright. The first two are typical Japanese medium long-grained varieties, while the Carolinas and Lady Wright represent the long types. Pure strains of these varieties were used, classified as follows regarding time taken to mature.

Early	Mid-Season	Late	Very Late
175–180 days Colusa Y 180	180–185 days Caloro Y 316	185–190 days Caloro Y 46 Carolina White Lady Wright	190–195 days Carolina Gold

FLOWERING

Jones cites observations by many workers, and times of maximum flowering ranging from 8–9 A.M. in Burmah (Thompstone) to 12–2 P.M. in California (Jones). The earliest and latest hours range from 5 A.M. in India (Ramiah) to 4 P.M. in California (Jones) and Texas (Laude and Stansel). Minimum temperatures for flowering are given, ranging from 59°F. in northern Japan (Akemine) to 77°F. in different parts of India (Bhide, Ramiah, Rao). Of the writers cited by Jones comparatively few give temperatures at which maximum flowering occurs: most, according to Jones, merely stating times. Ramiah is quoted as specifying 82 to 84°F. time varying, in India; Kobayasi 86 ± 3.6°F. in Japan, while Akemine, also in Japan but working with a different variety to Kobayasi, specifies 95 to 104°F. as optimum.

Noguti (formerly Kobayasi) alone is quoted as giving the relationships of both temperature and humidity to flowering. This worker who appears to have made a most comprehensive study of the subject, in a translation of the original paper, states that flowering takes place when the temperature at 8 A.M. amounts to about 80 to 83°F., increasing in activity up to 90°F. almost ceasing above this temperature, with 122°F. as maximum limit. Some of these observations were made in a thermostat: 70 to 80 per cent. is given as the most favourable degree of moisture, and the sudden change in humidity in the morning is said to be soon followed by the main flowering period. Below 70 per cent. moisture the number of florets opening is diminished, but flowering occurs even at 50 per cent., though rarely below 65 per cent. The temperature given, 86 ± 3.6°F., is said to be the optimum for flowering if the air moisture is below 70 per cent.

At Yanco rice has not been observed to commence flowering at a temperature below 72°F., humidity 62 per cent. It has been found that, in general, the lower the humidity the higher the temperature required to initiate flowering. Thus, with a humidity of 32 per cent. the temperature required was 81°F. Optimum conditions for flowering at Yanco appear to be a temperature of 85 to 90°F. and a humidity of 55 to 70 per

cent. This humidity is lower than that given by Noguti (or Noguchi), but the temperatures are similar. No varietal differences have been observed—the conditions which initiated flowering in any one variety have invariably brought it about in others at the same stage of development.

The maximum temperature and humidity for flowering have not yet been accurately determined at Yanco because by the time the temperature has risen to any high value in the field, the supply of florets ready to open has usually become exhausted. The highest temperature observed at which flowering occurs is 102°F., humidity 60 per cent., but there is no reason to suppose this the limit.

The time of day at which flowering commences varies very widely according to weather conditions; on a bright, clear day, with little or no wind, it usually commences between 8 and 9 A.M., reaches a maximum between 11-30 and 12-30 P.M., and ceases between 3 and 4 P.M. It has, however, been observed to occur at 6 A.M., with the maximum period between 9 and 10 A.M. and as late as 5-30 P.M. Wind and cloud, if slight, have the effect of postponing flowering, and if marked, can prevent it entirely; rain has a similar but more severe effect, in contrast to Noguti's experience in Japan. The amount of flowering curve follows the humidity curve with remarkable fidelity, but with a slight time-lag, as though the actual *variation* in humidity were an important factor.

Considerable evidence, which it is hoped to present in detail in a later article, is accumulating to indicate that between temperatures of 72 and 100°F. (and probably higher) humidity plays the principal part in determining the amount of flowering, and that other relevant factors act through humidity. For instance, wind arising while flowering is in progress has usually had a restricting effect, even though the temperature has risen.

Pollination

From a review of the literature Jones concludes that pollination just before or at the moment the flowers open is most usual, with comparatively rare cases in India (Bhide, Parnell, Parthasarathy) of pollination of some florets on a panicle after opening. This is also found to be the normal state of affairs at Yanco. Usually, in florets due to open on a given day, the anthers occupy a position about half-way up the glumes (in a short-glumed variety like Caloro relatively less in a long-grained variety) in the early morning of that day. When suitable temperature and humidity are reached the anthers can be seen approaching the apex of the glumes, the time taken from the half-way

position to reach one nearly touching the apex varying from thirty minutes at temperatures in the vicinity of 75°F., and comparatively high humidity, to two minutes or even less at about 90°F., humidity about 50 per cent. When the anthers almost touch the apex the glumes suddenly dehisce and spring apart as though under tension, their inner edges forming an initial angle of about 10 degrees. The tension appears to be provided by the lodicules which, as Akemine, according to Jones, reports, have swollen to about three times their former size at this stage. Through the opening thus made the anthers immediately commence to protrude.

At this stage three types of pollination can be distinguished :—

1. The anthers have burst, and pollination has taken place. This is comparatively rare at Yanco ; it has been observed only when the temperature is high (in the vicinity of 95°F.), and the humidity low (30 to 40 per cent.), which set of conditions has occurred usually only late in the afternoon, towards the close of the flowering period, when a steady hot dry westerly wind has arisen.

2. Anthers burst as they emerge, or within a few seconds, and pollination follows as the glumes continue separating. This is the most usual occurrence throughout the season and during the daily maximum flowering period with all varieties. The observed temperature range is 80 to 100°F., humidity 45 to 50 per cent.

3. At temperatures between 72 and 90°F., with humidity over 60 per cent., and particularly when the humidity has fallen steeply from a high value just prior to flowering while the temperature has risen, the anthers emerge unbroken, even damp. These conditions are comparatively rare at Yanco, occurring for any noteworthy period only on infrequent dull hot days, but more often for a short period in the mornings, about the commencement of the flowering period.

The filaments elongate rapidly, carrying the anthers out of the flower ; practically erect at first, the weight of the anthers bends the filaments over between the separating glumes. The anthers commence to dehisce at some stage in this process ; in extreme, but not infrequent cases, they are quite clear, and below the level of the floret. Pollen, in this case, is then very unlikely to fall on the stigmas of the same floret.

These three types are not clearly defined, but merge into one another. For instance, it happens sometimes that one set of three anthers bursts at emergence, the other triplet a few seconds later, when quite emerged. The actual dehiscence of the anthers is not violent ; it commences at the basal end, and pollen spills out gently as the split extends along

the anther. A slight change occurs in colour as the anthers mature, from a light yellow at the "half-way-position" (previously green) to a pale cream, almost white, the colour of the ripe pollen. The angle between the glumes, in the meantime, gradually increases to about 30°, very slowly towards the end, the total time occupied being about 60 to 180 seconds. Fruwirth is reported by Hayes and Garber to specify 30 seconds, while Copeland reports Mendiola as giving 6.5 to 6.9 minutes in the Philippines. The feathery stigmas gradually curve over, one to each side, and protrude in the angle between the glumes, covering the lodicules; they are usually slightly moist from the time they first become visible. In the usual course of events pollen falls thickly on the stigmas; in a few minutes this pollen changes colour from a pale cream to golden, even to a slightly orange tint, probably owing to absorption of moisture from the stigmatic surface and germination.

The flower remains open for a time varying from 13 to 75 minutes; this time, also, appears to be governed by the relative humidity of the air—the time is shorter at low humidity, and longer at high. The effect is probably due to desiccation of the lodicules, resulting in gradual slackening of the tension holding the glumes apart. Mendiola gives the time the florets remain open as fifteen minutes to two hours in the Philippines, Chiapelli one to two hours in Italy, Akemine, according to Jones, one and a half to two and a half hours in Japan. The glumes gradually close, pinching the flaccid filaments, and usually the withered or withering stigmas, one on each side, between them; these are not immediately severed, however, but usually persist for some time before falling. The glume edges do not interlock again until some hours after the floret has closed, usually the following night, when (and only if) the fertilized ovary has commenced to swell.

Pollination has not been observed to occur without opening of the floret, though Mendiola and Jones, reviewing observations in the Philippines, Java, India and Italy, state that closed pollination (cleistogamy) occurs in some varieties.

There is some difference in pollination among the varieties observed; the tendency of florets to open without immediate dehiscence of the anthers is more marked in long-grained varieties, because the distance the anthers have to be carried before reaching the apex of the glumes is greater, and in the meantime these have possibly opened. The sudden dehiscence of the glumes may be a means of bursting the ripe anthers, which are probably less susceptible to shock when not in close contact with the apex.

Natural Crossing

Jones, in concluding his review of literature on natural crossing, states: "....natural crossing in rice ranges from practically none in Hawaii and California to as high as 23 per cent. in Java. Climatic conditions appear to have a marked effect upon the extent of natural crossing. In Japan and Java high humidity and low temperature seem to favour natural crossing, while low humidity and low temperature are more favourable for autofecundation. The extent of natural crossing in rice also depends upon the peculiarities of the variety grown, as was observed in Japan and Java. Other external factors which influence the extent of natural crossing in rice are wind velocity, rain, and insects of various kinds which visit the florets while in bloom."

Mendiola states that natural hybrids are being continually produced in the Philippines, and ascribes to the effects of natural crossing the unsteady yield performance of different supposedly pure lines. Jones reports Ikeno, in Japan, as concluding that "crossing is very rare in nature," while Hoshino, quoting Kato, also in Japan, states that natural crossing often occurs.

The great importance of natural crossing in accounting for the very numerous varieties of rice grown in the world, often many in one small district, and the constant occurrence of variations in commercial crops has been stressed by many writers. As a source of new varieties Mendiola refers to natural crossing as "both the hope and despair of the rice breeder."

Natural crossing is known to occur at Yanco:

1. By the repeated discovery in supposedly pure lines growing in the stud plots, of variant types whose subsequent behaviour has shown them to be unfixed crossbreds.

2. By the diversity of types encountered in field crops, originally apparently homogeneous. To take a specific instance, by the rapid increase in the percentage of red rice in one variety, Colusa. The proportion increased from about .05 per cent. in 1926 to nearly 6.5 per cent. in 1930, when the variety was withdrawn from cultivation. Natural crossing must be invoked as an explanation, keeping in mind the Mendelian dominance of the red grain factor (s), for possible increase due to earlier ripening and shattering of a red-grained variety present as admixture will not hold, as weeds do not usually permit the growing of rice in two successive seasons on the same land.

3. By experiments carried out in the stud plots with varieties of similar maturity differing in some marked character. Caloro Y 46 was

grown in a row spaced 2 links (40 cm.) from a late red-grained selection in 1930. Of 2,017 plants grown from seed from the Caloro Y 46 row in 1931, nine were red-grained, equalling 0.044 per cent. natural crossing. Segregation counts in 1932 showed the particular red-grain factor involved to be a simple Mendelian dominant. The rate of natural crossing is probably much higher under field conditions, where rice is drilled in 7 inches (13.5 cm.) apart, and plants touch one another in the drills. Further experiments are under way to determine this point, also to ascertain the maximum distance over which natural crossing can be expected to occur.

Temperature and humidity are certainly important factors influencing pollination, as pointed out under the previous headings "Flowering" and "Pollination," and therefore natural crossing. Wind is important as a ready means of conveying pollen over very considerable distances. Mendiola gives a table showing the distances wind-borne pollen will travel at various wind velocities. He considers 6.5 feet (2 m.) apart a safe distance for sowing rows of different varieties to avoid natural crossing. Bees are frequent visitors to rice in bloom. I am indebted to Mr. P. C. Hely, Departmental Entomologist on the Area, for identification of the following insects observed in association with rice heads in bloom: Honey Bee (*Apis mellifica*), Pumpkin Beetle (*Aulacophora olivierii*), Black Flea Beetle (*Haltico ignea*), Rice Beetle (*Laius femoralis*).

Summary

Flowering

1. Temperature and humidity are closely interrelated in governing flowering, and, within limits, in inverse ratio.

2. The minimum temperature at which flowering occurs is 72°F. if the humidity is not less than 62 per cent.

3. Maximum flowering occurs when the temperature is 85 to 90°F., and humidity 55 to 70 per cent.

4. The highest temperature at which flowering has been observed to occur is 102°F., humidity 60 per cent.

5. The response of all varieties observed to a given set of conditions was the same.

6. The time of flowering varies with weather conditions; it usually commences at 8.30 A.M., reaches a maximum between 11–30 A.M. and 12–30 P.M., and ceases about 3–30 P.M.

7. Observed extremes in flowering time are 6 A.M. and 5–30 P.M.

8. Wind, clouds and rain adversely affect flowering.

9. Relative humidity is the most important factor governing the amount of flowering between temperatures of 72 and 100°F. The variation of humidity appears to play some part.

10. The normal humidity during the flowering period of rice is unusually low at Yanco in comparison with published data for other countries.

Pollination

1. Three types of pollination occur—
   (*a*) Before the florets open—when the temperature is high (about 95°F.) and humidity low (about 35 per cent.) ; rare.
   (*b*) At opening of the florets, or within a few seconds—when the temperature is 80 to 100°F. and humidity 45 to 50 per cent. ; usual.
   (*c*) After the florets have opened—when the temperature is between 72 and 90°F., and humidity high (over 60 per cent.) ; not infrequent.

2. The glumes open to a maximum angle of about 30 degrees in from one to three minutes, and remain open for thirteen to seventy-five minutes. This time is apparently governed by the relative humidity of the air.

3. Cleistogamy has not been observed to occur.

4. Pollination is more likely to occur after, rather than at opening of the florets in long-glumed varieties than in short-glumed varieties.

Natural Crossing

1. Natural crossing is known to occur at Yanco—
   (*a*) By the discovery of occasional heterozygotes in supposedly pure lines.
   (*b*) By the diversity of variant types increasingly occurring in commercial crops.
   (*c*) By experiment in the stud plots ; 0.044 per cent. natural crossing observed at 2 links (40 cm.)

2. In addition to temperature and humidity, wind is an important factor.

3. A list is given of insects observed in association with rice in bloom.—*The Agricultural Gazette of New South Wales*, Vol. XLIII, Part 12.

1457-34.—Printed at The Bangalore Press, Mysore Road, Bangalore City by T. Subramania Aiyar, Superintendent.